Acoustics in the Worship Space IX

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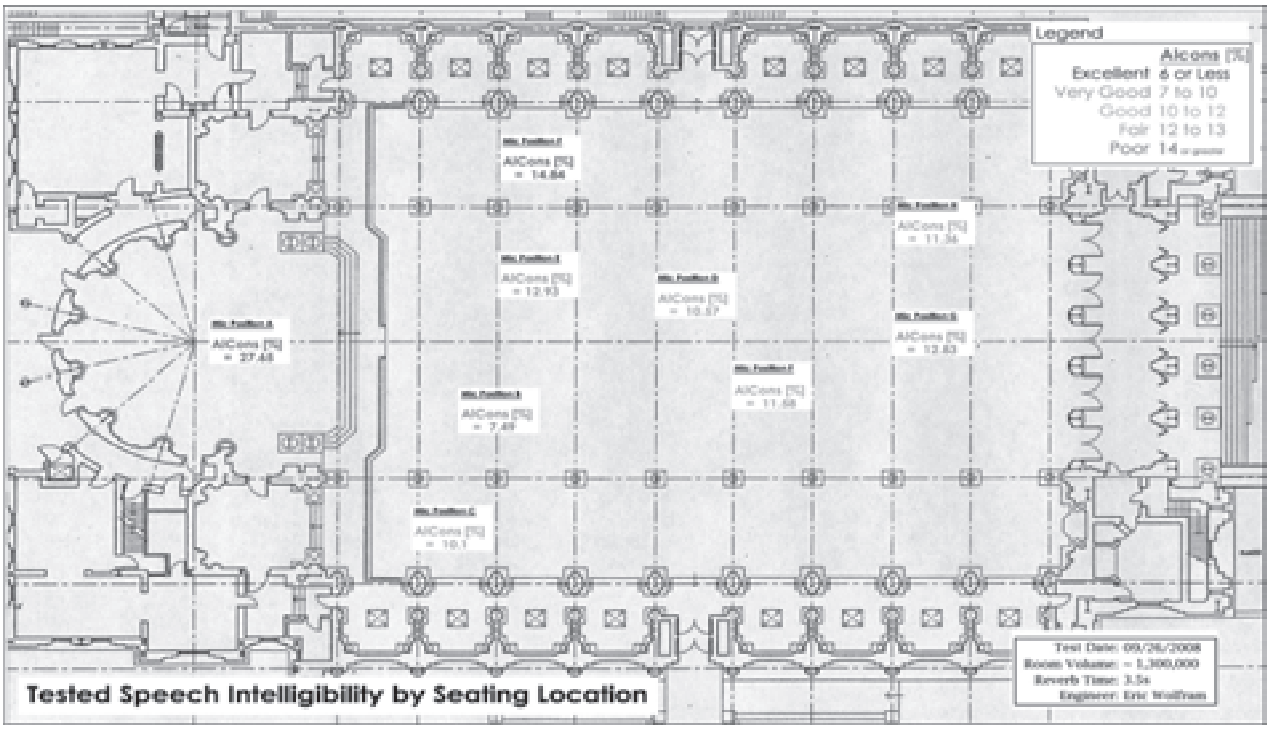
Acoustics in the Worship Space I, II, III, IV, V, VI, VII, and VIII have appeared in The Diapason*, May 1983, May 1984, January 1986, May 1987, April 1988, April 1990, July 1991, and May 1992 respectively.*



Alcon measurement data map

The Value of Good Acoustics

My over eighty-year-old grandmother once declared, "The new pastor at church is just no good!" The rest of the family was surprised by this statement to say the least; we all thought grandmother's new pastor was quite a fine man, and a good preacher, too. So—we tactfully inquired of grandmother, "Just what don't you like about him?" I'm not just sure what we imagined her answer would be, but we were again surprised by the response: "He's no good because you can't hear him!" The cause of my grandmother's stated perception of the pastor may have been issues with aging, hearing aids, room acoustics, or sound system performance—but no matter the cause, perception was reality to my grandmother!

The value of good sound rendition in worship cannot be underestimated. Worship is a multi-sensory experience. It is expressed in *sound* through speech and music. It is expressed in *sight* through art, architecture, and image. It is expressed in *touch* through material texture and human interaction. And it is expressed through *taste* and *smell* in such means as bread, wine, flora and incense. The primary mode of communication in most worship contexts, however, is through the sense of *sound*. The sounds of worship are many and diverse. There is the speech of sermon, lessons, liturgy and prayers spoken by clergy, lay assistants, and the assembly—and spoken from altar, pulpit, lectern, ambo, font, nave, balcony, transept and pew. There is the traditional and contemporary music of choir, organ, percussion, woodwind, brass, and string—projected from chancel, balcony, transept, or stage. There is the essential participation in hymn and song by the assembled congregation, projected to and heard from every corner of the room. There is the sound delivered by speakers—reinforced speech or music, and the host of aural media forms. One only needs to imagine a worship experience lacking any sound communication in order to contemplate the extreme importance of such sound communication!

Given the functional use, the communicative formats, and the artistic possibilities of sound in worship, what is the appropriate application of time, talent, and treasure to achieve good acoustics in the worship environment? The answer might be found in considering the definition of the word "good" in this context.

In terms of speech intelligibility, "good" can be scientifically determined: "Alcons"—the measure of speech clarity, is defined as the Articulation Loss of Consonants. A "low" Alcon percentage (0–6%) is considered "excellent," and indicates that a listener "loses" only from 0 to 6 of 100 words spoken. An Alcon percentage of 7–10% (indicating 7 to 10 words "lost" out of 100) is "very good," and an Alcon percentage of 10–12% is "satisfactory." An Alcon percentage of 13% is "marginal," and greater than 14% is "unacceptable." "Good" acoustics for speech, therefore, suggests a combination of architectural acoustic design and sound system components that can achieve a measurable 7–10% Alcons within a room.

In the "old days" Alcons were measured by "live test subjects." A group of "subject" persons were placed in a room, and a narrator read a list of words to them. The "subjects" noted what words they thought they heard on a survey sheet, and the answers were complied. The Alcons were determined by the percentage of right and wrong survey answers! Now: a computer generates a "sweep" of multi-frequency sound that is played through speakers into a room. The computer also receives this sound via microphones, analyzes/compares the sweep sound generated and received, and then computes the Alcons.

Scientific measure can be applied to other acoustical factors. Through empirical testing, "good" and functionally appropriate reverberation periods can be determined for worship. The reverberation period is the time (measured in seconds) that a sound takes to drop 60 decibels in intensity after the source ceases producing the sound—it is the length of time audible sound "lingers" in a space. Churches using liturgical worship styles that may include choral and organ music with chanting should be in the 2.0 to 3.0 second reverberation time range, while churches using contemporary music styles should be in the 1.4 to 1.8 second range. Congregations using differing or "blended" styles within the same room might consider a system of altering the room's reverberation period to meet their needs. The appropriate reverberation period will be an important factor in achieving speech and music clarity, musical blend, and reinforcing support for the singing congregation. "Good" reverberation times then can result from the design and balance of room size, shape, layout and proportion of sound reflecting to absorbing interior finish materials.

In the "old days" an impulse sound was generated in a room (by a balloon burst or starter pistol shot, etc.), and that sound was recorded on a graphic chart recorder and sound recording. The reverberation time was measured off the graph recorder and in time. Now: the same sweep sound as used for Alcon testing is generated and received by the computer, such that the computer can measure/compute the reverberation time period.

Through empirical testing, "good" and functionally appropriate background noise levels can also be determined for worship. In this context, "NC" (Noise Criteria) is the measure of the intensity of ambient background noise across the frequency range. In order to avoid masking or interrupting desired expressive speech and music, the allowable noise criteria for worship is typically NC 25–30. "Good" and low ambient background noise levels can result from careful design, placement and attenuation of mechanical system and activity noise.

In the "old days" a decibel meter was set up and monitored to take in "background noise" data. Now: background noise is still measured by a multi-frequency decibel meter.

There are a host of factors and individual circumstances to be taken into consideration when designing or remodeling a worship space. The allocation of resources sufficient to achieve at least a "good" acoustical setting for speech (Alcons), general sound quality (Reverberation Time), and noise control (NC) is essential, and can be the beginning of the path to a truly excellent sacred environment. ■

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Eric Wolfram, head acoustician/testing engineer for Scott R. Riedel & Associates, Ltd., assembled the illustrations.

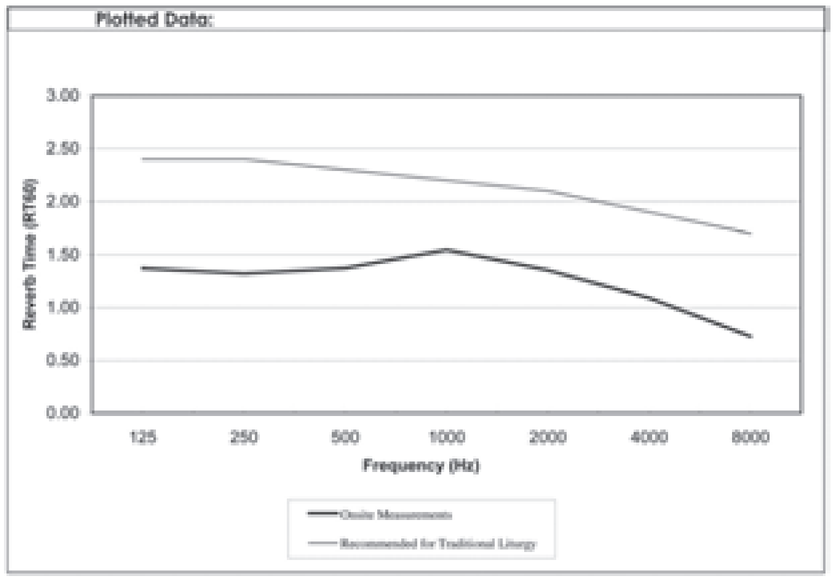
Eric Wolfram conducting acoustical testing with computer, microphones, speakers, and sound-generating equipment

Reverberation Time Measurement

reference: ISO 3382:1997(E)

	Walls: Plaster Walls with Portions Thin Wood Wainscoting
Test Date: January 3, 2009	Ceiling: Stiff, Heavy Wood Deck Ceiling Throughout
Engineer: Eric Wolfram	Floor: Thick Carpeting Throughout
Rm. Volume: 124,000.00 Ft³	Seating: Padded Pew Seats and Backs
Tested Occupancy: Fully Unoccupied	Atmosphere: 64.6 °F 33.8 % RH

Plotted Data:



Onsite Measurements

T30 (Reverberation Time)

Hz	Pos. A	Pos. B	Pos. C	Pos. D	Pos. E	S.D. σ =	Average	Recommended for Traditional Liturgy
125	1.39	1.49	1.46	1.44	1.08	0.17	1.37	125 2.4
250	1.29	1.33	1.32	1.4	1.3	0.04	1.32	250 2.4
500	1.41	1.36	1.43	1.4	1.3	0.05	1.37	500 2.3
1000	1.68	1.62	1.56	1.6	1.3	0.16	1.55	1000 2.2
2000	1.38	1.62	1.52	1.5	0.6	0.44	1.35	2000 2.1
4000	1.27	1.28	1.25	1.2	0.5	0.34	1.09	4000 1.9
8000	0.83	0.76	0.75	0.7	0.6	0.09	0.75	8000 1.7

EDT (Early Decay Time)

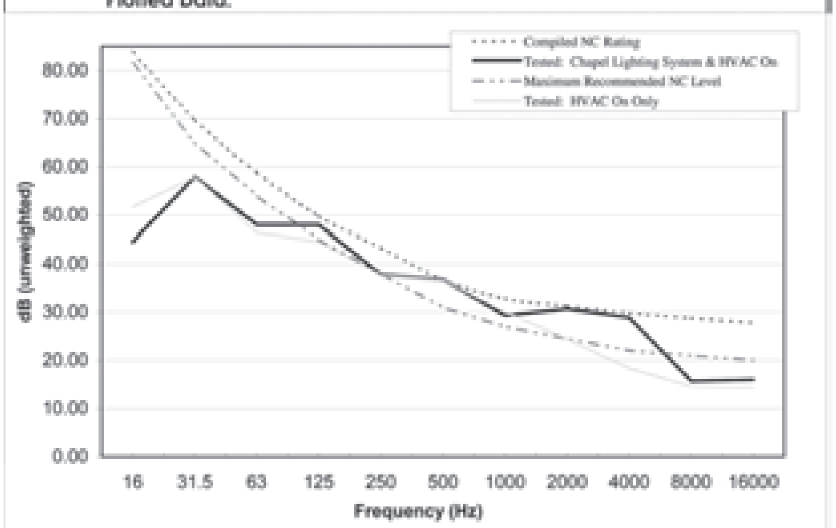
Hz	Pos. A	Pos. B	Pos. C	Pos. D	Pos. E	S.D. σ =	Average
125	1.23	1.17	1.60	1.27	1.08	0.20	1.27
250	1.48	1.36	1.61	1.2	1.3	0.18	1.38
500	1.32	1.44	1.44	1.3	1.3	0.09	1.35
1000	1.22	1.40	1.41	1.6	1.3	0.14	1.38
2000	1.25	1.36	1.43	1.7	0.6	0.42	1.26
4000	1.13	1.11	0.74	1.3	0.5	0.33	0.95
8000	0.95	0.69	0.66	0.8	0.6	0.14	0.74

	Pos. A	Pos. B	Pos. C	Pos. D	Pos. E	Average	Recommended
C_{50} (Definition / Speech)	-1	5.2	4.20	2.5	5.7	3.32	Recommended C_{50} ≥ -2 dB
C_{80} (Clarity / Music)	1.00	6.40	6.60	4.3	8.2	5.30	Recommended C_{80} ≥ -5 dB

Noise Test Results and NC Rating

Client:	Building: Sanctuary
Test Date: 9/26/2008	Room Number:
Rm. Volume: 1,300,000.00 Ft^3	Engineer: Eric Wolfram
Rm. Notes:	Condition: **HVAC Fan On, Chapel Lighting System On** Tones Present in Lighting System dimmer circuit: 33.89dB@ 1.55 kHz, 31.61 dB@ 2.15kHz, 31.02dB @ 2.28 kHz

Plotted Data:



Compiled NC Rating
NC 31.8

Sound energy time curve, showing both reverberation time and an echo